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ABSTRACT

The Fama-French (FF) three factor model expands the capital asset pricing model (CAPM) to include two additional factors to the market factor – SMB, employed to capture a firm size effect in returns and HML employed to capture book-to-market effects in returns. In the UK, different researchers use different ways of calculating SMB and HML in the context of empirical applications of the three factor model, or extensions of it, perhaps because they believe the differences in the construction of the SMB and HML factors to be relatively unimportant from an empirical standpoint. We investigate whether indeed factor construction methods are unimportant. Our conclusion is that they do matter.

Keywords: asset pricing, book-to-market, Fama and French model, size

JEL Classification: G11, G12, G14, G15, M41

1 INTRODUCTION

The Fama-French (FF) three factor model (Fama and French, 1993, 1996) expands the capital asset pricing model (CAPM) to include two additional factors to the market factor. One – SMB – is employed to capture a firm size effect in returns. The other – HML – is employed to capture book-to-market effects in returns. In the USA, the estimation of the latter two factors has become increasingly standardised - versions are available from French's website.[1] In the UK, however, the situation is different and different (sets of) researchers use different ways of calculating SMB and HML in the context of applications of the three factor model, or extensions of it, perhaps because they believe the differences in the construction of the SMB and HML factors to be relatively unimportant from an empirical standpoint.

The plethora of methods used in estimating SMB and HML in the UK raises questions. Do the various ways of constructing SMB and HML produce similar factors in terms of their sample means? Further, given that these factors are meant to capture risk effects attributable to differences in firm characteristics, are the sample means of the various SMB and HML factors significantly different from zero? Then, we can ask whether the various SMBs and HMLs are correlated with each other (do they contain similar information)? Finally, as a case study of the impact of the different methods of estimating SMB and HML, we can ask whether it matters if the various SMB and HML factors have different characteristics if various FF three factor models based upon these factors are similar to each other with respect to the pricing of specific sets of test portfolios?[2]

[1] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french

[2] Also, we focus on the FF three factor model because that is the context in which the use of SMB and HML arose.

There is a contribution in pursuing our line of enquiry because, although FF three factor-based models employing SMB and HML have been used in empirical research on UK data, relatively little formal testing of the performance of any of these models, or the factors employed, has taken place (see the next section for exceptions). Given the prominence of three factor models in empirical work, understanding the performance of these models in UK, and, in particular, whether performance is affected by the different methods of estimating SMB and HML, seems an important area of study. Further, some empirical researchers expand the FF three factor model to include other factors (for example, a momentum factor, to produce a UK version of the Carhart (1997) model, as studied in the UK by Gregory *et al* (2013)). Within such expanded models, an understanding of the properties of the various methods of estimating SMB and HML is still important. Overall, in the absence of an enhanced understanding of the performance of the various models, and the characteristics of their components, it is difficult to evaluate the validity of previous research findings dependent upon the use of specific versions of SMB and HML.

Given the objectives and questions outlined above, we perform a number of tests related to the different construction methods for SMB and HML. First, we ask whether the means of the monthly time series of the various SMB and HML factors significantly differ from zero. Second, we examine the correlations between the various SMBs and HMLs to assess the degree of similarity between them. Third, we specifically focus on asset pricing tests of the various three factor model applications we identify. We use time series regressions to ask whether the different three factor models price two sets of test portfolios, one set of sixteen portfolios constructed on the basis of size and book-to-market rankings, and the other a set of twenty industry portfolios, in a similar fashion.

Our data suggests that size appears to be associated with UK returns, although the association is concentrated in the bottom 30% of firms. For larger firms, there appears to be no obvious association. There does appear to be a reasonably clear association between UK returns and the book-to-market ratio. Despite these apparent associations, however, assessing the means of the various SMB and HML factors *via* t-tests suggests that they are not always significantly different from zero. For SMB, five out of nine estimates indicate significant small firm size *premia*. For HML, four out of nine estimates provide significant value *premia*. For correlations between different methods of constructing SMB and HML, we conclude that, although there is overlap in the information contained in the various factors, there is also a substantial degree of dissimilarity.

Our results from the asset pricing tests strongly reject the null hypothesis that *any* of the three factor models adequately price the test assets created by rankings of firms by size and the book-to-market ratio. Further, no specific pattern emerges as to which particular size/book-to-market portfolios are mispriced. When industry portfolios are used as the test assets, however, we cannot reject the null hypothesis that the pricing errors are jointly zero for four of the three factor models.

Overall, we conclude that different ways of estimating the SMB and HML factors can result in quite different characteristics for the factor time series means. Further, the correlations between the various SMB and HML factors suggest a degree of dissimilarity between them. If previous researchers believed that methods of operationalising the SMB and HML constructs were not important in empirical settings, our asset pricing results suggest otherwise. Within the context of FF three factor-based asset pricing tests, some models acceptably price industry portfolios, but some do not. Further, in pricing size/book-to-market portfolios, none of the models performs acceptably and, further, no particular pattern can be discerned as to which size/book-to-market portfolios are consistently priced by all models.

The paper proceeds as follows. Section 2 provides a review and discussion of prior literature. Section 3 describes the methodology for performing asset pricing tests. Section 4 describes the data, sample and the factor characteristics, with particular emphasis on the estimation of SMB and HML using the methods described in the nine papers studied and the construction of the two sets of test portfolios. Section 5 reports the empirical results. The final section summarises the results and offers conclusions.

2 PRIOR LITERATURE

There is limited evidence of how particular versions of SMB and HML perform on UK data, usually in the context of a FF three factor-based model. There are exceptions, however. For example, Miles and Timmerman (1996) compare the CAPM, a two factor model consisting of just SMB and HML as factors, and a three factor model on UK data. Using sixteen portfolios sorted on both size and the book-to-market ratio, their results, taken at face value, suggest that the two factor model is superior in explaining the sixteen time series of portfolio returns relative to the other pricing models. Fletcher (2001) evaluates a number of asset pricing models on UK data, including a three factor model. He warns against the indiscriminate use of any of the factor models he investigates. Hussain, Toms and Diacon (2002) investigate the properties of a three factor model based upon Fama and French (1993) and conclude that it performs better than the CAPM in pricing various sets of portfolios formed by ranking firms according to a number of different criteria, although mispricing appears to occur for various portfolios when a three factor model is used.

What is striking about the papers using UK data referred to in the paragraph above is that, in each of them, the SMB and HML factors are constructed in *different* ways. For example, Fletcher (2001) uses equally-weighted returns in constructing SMB and HML. In contrast, Hussain *et al* (2002) use value-weighted returns. Miles and Timmerman (1996) also use value-weighted returns, but form the portfolios making up SMB and HML on May 1 each year over their sample period, whereas Fletcher (2001) and Hussain *et al* (2002) form them on July 1. Further, Miles and Timmerman (1996) use a set of firms restricted to possessing full data over their sample period, whereas Fletcher (2001) and Hussain *et al* (2002) impose no such restriction. Obviously, it becomes difficult to aggregate the information in these studies about the performance of three factor models when each one uses a different version of the three factor model.[3]

Further, have versions of three factor models been used in empirical settings in the UK, irrespective of the relative lack of support for its efficacy in the UK? The answer is yes. For example, Liu, Strong and Xu (1999) study the profitability of momentum investing. As part of their study, they find that a three factor model cannot explain the returns of portfolios formed on past returns. Gregory, Harris and Michou (2001) study the profitability of value investment strategies. They find that a three factor model can explain returns for portfolios formed on the basis of sorting firms by a single measure of value. Nonetheless, the three factor model cannot explain portfolios formed by sorting on sales growth and one of the ratios of book to market, earnings to price or cash flow to price. Depending upon the

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[3] Other examples where UK data is used to explicitly evaluate the performance of three factor models include, for example, Fama and French (1998), Bauer, Cosemans and Schotman (2010) and Fama and French (2011). Unfortunately, sometimes when UK data has been used on its own (e.g., Fama and French, 1998), the data employed has been severely restricted relative to that actually available. Alternatively, UK data has been merged with other non-US data (as in Bauer *et al*, 2010, and Fama and French, 2011) and, as a consequence, the ability to evaluate the performance of three factor models on the UK alone is lost.

research viewpoint adopted, the two studies, and others like them, provide additional evidence on the performance of three factor models in the UK, if it is assumed that the portfolios investigated are correctly priced by the market. Alternatively, if the particular three factor model is accepted as valid, the results point to market inefficiency.

Again, what is striking about the two papers mentioned in the previous paragraph is that not only do they use different methods of constructing SMB and HML from each other but also their methods are different from those used by Miles and Timmerman (1996), Fletcher (2001) and Hussain *et al* (2002). Indeed, further inspection finds a number of other papers using versions of the three factor model, including Fletcher and Forbes (2002), Al-Horani, Pope and Stark (2003), Dimson, Nagel and Quigley (2003), and Fletcher and Kihanda (2005), that provide yet more ways of constructing SMB and HML.

Overall, researchers using UK data have constructed SMB and HML in a number of different ways. Nine sources of different factors are identified above. And, although we emphasise the UK context, Balvers (2001) writes, in connection with the construction of SMB and HML from a set of benchmark portfolios, 'Why they create six [benchmark] portfolios instead of nine or four is not clear. Fama and French admit that the choice is arbitrary but that they have not searched over alternatives. Typically, however, researchers cannot get away from arbitrary choices such as these.' As a consequence, factor design is potentially problematic in the USA too, although the existence of factors downloadable from French's website might, as a purely practical matter, have achieved a degree of standardisation. Nonetheless, the key issue here is that the construction of SMB and HML is arbitrary, even in the USA. As a consequence, we would argue that the performance of various ways of constructing factors, whether in the US, the UK, or anywhere else, is an empirical issue.

3 ASSET PRICING TESTS

As our asset pricing methodology, we use the standard Fama and MacBeth (1973) first stage methodology, using the excess returns on a set of test portfolios to evaluate the pricing performance of various asset pricing models. We estimate exposures of the test portfolios to the market factor, HML, and SMB by estimating time series regressions of portfolio monthly excess returns against the three factors. For each portfolio, we first estimate the equation below:

$$R_{it} - R_{ft} = a_i + \beta_{iM}(R_{Mt} - R_{ft}) + \beta_{iHML}HML_t + \beta_{iSMB}SMB_t + \varepsilon_{it}, \forall i, \quad (1)$$

where:

R_{it}	is the return for portfolio i for period t;
R_{ft}	is the risk-free return for period t;
a_i	is the intercept term for portfolio i;
β_{iM}, β_{iHML}, and β_{iSMB}	are the exposures of portfolio i to R_M, HML, and SMB respectively;
R_{Mt}	is the return on the market for period t;
HML_t, SMB_t	are the value and size factors respectively for period t; and
ε_{it}	is an error term for portfolio i for period t.

We estimate the exposures of the portfolio excess returns to the market factor, SMB and HML, using 60 month rolling multiple time series regressions. That is, we run the regressions in equation (1) each year using 60 months of observations (for example, July 1980 to June 1985). Then, we roll the regression period forward 12 months (for example, to the period from July 1981 to June 1986). We start this process from the beginning of the period covered by the data that we use for the tests and carry on until we run out of data for the estimation of exposures. At the end of the process, we have a time series of monthly intercepts for each portfolio.

Our procedure allows time variation in intercepts and exposures. We adopt this approach because Ang and Chen (2007) suggest that allowing time-varying betas in the US can lead to the conclusion that conditional versions of the CAPM successfully explain a large portion of the value and size *premia*. Also, Ecker (2012) recommends using time-varying betas because they do not incorporate information in future returns. Further, Avronov and Chordia (2006), again using US data, suggest that a conditional three factor model could be superior to an unconditional one.[4, 5]

If a factor model captures risk effectively, it is expected that the intercept terms for each portfolio will average zero. Hence, as part of our investigation, we report estimates of the average intercepts computed in the time series regressions, their associated individual t-statistics, and present a joint test of the significance of the average intercepts across the set of test portfolios, by applying the Gibbons *et al* (GRS) (1989) test, using the test statistic in Cochrane (2001).[6]

4 We appreciate that allowing time-varying exposures is not equivalent to estimating a conditional factor model in the absence of specifying the variable or variables that generate time variation in the exposures.

5 As a robustness check, however, we also run unconditional models over the complete data period. It makes no difference to our conclusions based upon asset pricing tests.

6 Kan and Zhang (1999) also suggest testing whether the loadings of the assets with respect to a particular factor are jointly significantly different from zero in the first pass time-series regressions before running the second pass cross-sectional regressions. We also test for the joint significance of the factor coefficients using an F-test which treats the test portfolio time series regressions as seemingly unrelated.

4 DATA AND SAMPLE

The sample period covered in our study for firm returns is from July 1980 to June 2010. The empirical analysis uses annual accounting data from Datastream, and monthly return data from the London Share Price Database (LSPD). We *include* in our sample companies that have been de-listed from the exchange due to merger or bankruptcy etc. We *exclude* companies with more than one class of share, companies with negative book-to-market ratios, and companies that belong to the financial sector (banks, insurance companies, investment funds, unit trusts and property companies). The distribution of firms across the years is described in Table 1 below.

Insert Table 1 About Here

Given the firms in each annual cross-section, and in order to initially investigate whether size and book-to-market (BM) effects manifest themselves across our annual samples of stocks, we sort stocks into deciles (P1 being the lowest and P10 being the highest) according to size and BM on June 30 of every year. Firm size is measured as the number of shares outstanding multiplied by the stock price at the end of June in each year. BM is measured at the end of December of previous year.[7] We report the monthly average and value-weighted returns for these deciles over the period July 1980 to December 2010. The results are shown in Table 2.

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[7] Specifically, the BM used to sort stocks on June 30 of year t is measured using the firm market value at the end of December year t-1. Book value is taken from the balance sheet for the financial year ending during the calendar year t-1. Book value is defined as equity capital and reserves (net assets) minus total intangibles – one of the more common definitions for book value used in the UK.

Insert Table 2 About Here

Panel A in Table 2 suggests the existence of a univariate size effect over the period, in that the average and value-weighted returns on the smallest size decile are higher than those for the remaining deciles. However, there is no clear-cut monotonic relationship between size and returns beyond P4. Therefore, for the period studied, the size effect seems mainly due to the smallest firms.

When sorting stocks into deciles according to BM (Panel B), we find that the highest BM decile significantly outperforms the remaining deciles. Further, a generally upward sloping relationship between BM and returns can be observed for average returns, whether for equally-weighted or value-weighted returns. Generally, however, a BM effect appears to be at work in the UK stock market over the period.

As mentioned above, research papers in the UK have used various methods to construct SMB and HML factors. We identify different methods from the papers we surveyed and, hence, initially we create nine different sets of SMB and HML factors. The nomenclature for the factors is to add the first letters of the relevant authors to SMB and HML to denote from which paper factor estimation methods are derived from. Thus, APS denotes Al-Horani *et al* (2003), DNQ denotes Dimson *et al* (2003), F denotes Fletcher (2001), FF denotes Fletcher and Forbes (2002), FK denotes Fletcher and Kihanda (2005), GHM denotes Gregory *et al*

(2001), HTD denotes Hussain *et al* (2002), LSX denotes Liu *et al* (1999), and MT denotes Miles and Timmerman (1996).[8]

There are a number of issues that are important to the estimation of the SMB and HML factors and which differ across the papers surveyed. The generic method of constructing the factors is based upon linear aggregations of the returns of various portfolios formed on the basis of the size and the book-to-market ratio of firms. The issues that arise in forming these portfolios are as follows:

(i) the *definition* (including date) of size and book-to-market;

(ii) the *date* on which the ranking of firms into size and book-to-market portfolios takes place;

(iii) whether the portfolios are formed by *independent* or *sequential* sorts of firms by size and book-to-market;

(iv) the *break points* used to create the underlying portfolios from which the SMB and HML factors are created; and

(v) the *weights* used in forming portfolio returns (equal- or value-weighted; how often weights are updated).

[8] The nine methods we identify are not intended to be complete as a description of the range of methods used in constructing SMB and HML in the UK. For example, Gregory (1997) constructs these factors on the basis of single dimensional sorts. We do not test out this method of factor construction if only because Gregory's views on factor construction evolved over time to the use of two dimensional sorts to create factors, as in GHM. Other methods can be found in, for example, Antoniou, Galariotis and Spyrou (2006), who also use single dimensional sorts, but with different breakpoints from Gregory (1997). Again, we do not test out this method because Antoniou *et al*'s (2006) views on factor construction also appear to have evolved over time, as illustrated by the use of two dimensional sorts, along the lines of Fama and French (1993), in Alexandridis, Antoniou and Petmezas (2007). We keep in the multiple methods employed by Fletcher and his colleagues because they illustrate some interesting construction issues. For example, Fletcher (2001) and Fletcher and Forbes (2002) differ in only one way, given the factor construction details available – Fletcher (2001) constructs factor portfolio returns using an equally-weighted approach, whereas Fletcher and Forbes (2002) use the value-weighted approach.

4.1 Definitions of size and book-to-market

There is ambiguity regarding the market value figure that is used in the calculation of BM. Of the papers surveyed, only five state clearly how this figure is computed. Most of those which disclose their method use the market value at the end of December to compute BM. Gregory *et al* (2001) and Liu *et al* (1999), however, use the end of June market value to calculate BM.

When it comes to the definition of the book value of equity, differences emerge. Three papers use equity capital *plus* reserves *minus* total intangibles as the book value of equity (i.e., Gregory *et al*, 2001, Hussain *et al*, 2002, and Liu *et al*, 1999). Fletcher (2001) and Fletcher and Forbes (2002), Miles and Timmermann (1996) and Al-Horani *et al* (2003) use equity capital *plus* reserves as the book value of equity. Dimson *et al* (2003) define the book value of equity as ordinary share capital *plus* reserves *plus* deferred and future taxation. Table A.1, Panel A in the Appendix provides a summary of the definitions used for book value.

4.2 Dates at which underlying portfolios are formed

Portfolios of stocks are formed annually at the start of July for all the papers apart from Miles and Timmermann (1996) where portfolios are formed at the start of May each year. In the current study, then, to be included in the sample for year t, firms must have the data for BM in December of year *t-1,* and at least one return observation for the 12 months over the holding period.[9]

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[9] The proceeds from a delisted stock are distributed among other stocks in the portfolio on the basis of their weights. As in Liu *et al* (1999), we correct for delisting bias by adjusting the delisting returns to -100 percent whenever the LSPD death type is liquidation (7), quotation cancelled for reason unknown (14), receiver appointed/liquidation (16), in administration (20), or cancelled and assumed valueless (21).

4.3 Portfolio formation sorting method

Three different sorting methods are used by the examined papers. The most popular sorting method, and the one applied by Fama and French (1993, 1996), is the independent sort. Illustrating this method of portfolio formation, and assuming a sorting date of the end of June, for each year *t*, stocks are allocated into two groups, i.e. small (S) or big (B), based on their market value. Stocks are also allocated in an independent sort to three BM groups, low (L), medium (M) or high (H). Firms with negative BM are excluded from the sorts.

Six size - BM portfolios (S/L, S/M, S/H, B/L, B/M, B/H) are created from the intersections of the two size and three BM groupings. Monthly returns for the portfolios are calculated for the 12 months from July of year *t* to June of year *t*+1. The size factor (SMB) return is defined as the difference each month between the average of the returns on the three small portfolios (S/L, S/M, S/H) and the average of the returns on the three big-stock portfolios (B/L, B/M, B/H). The book-to-market factor (HML) return is defined as the difference between the average of the returns on the two high BM portfolios (S/H, B/H) and the average of the returns on the two low BM portfolios (S/L, B/L).

Hence, the risk factors are calculated as:

$$SMB = (S/H+S/M+S/L)/3 - (B/H+B/M+B/L)/3$$

$$HML = (S/H+B/H)/2 - (S/L+B/L)/2$$

This basic method is employed by Miles and Timmermann (1996), Liu *et al* (1999), Gregory *et al* (2001), Hussain *et al* (2002), Al-Horani *et al* (2003), and Dimson *et al* (2003).

The second sorting method is the subsequent sort where, each year, stocks are categorised first into two size groups. Then, *within each size group*, stocks are sorted into three BM groups. The factors are then calculated as above. This method is used by Fletcher (2001) and Fletcher and Forbes (2002).

The main difference between these two sorting methods is the number of stocks allocated to each of the six size-BM portfolios. In other words, the subsequent sorting method results in exactly the same proportion of stocks in each of the three portfolios within each size group, whereas this is not necessarily true for the independent sorting approach.

The only paper that uses neither the subsequent sort nor the independent sort is Fletcher and Kihanda (2005). They construct SMB using portfolios sorted by only size. To construct the HML factor, they used the difference in monthly returns between the Morgan Stanley Capital Investment (MSCI) UK value and growth indices. Table A.1, Panel B provides a summary of the sorting methods used.

4.4 Size and book-to-market breakpoints

The examined papers apply four different methods to define the market value break points which distinguish between ‘small’ and ‘big’ firms. The most common method used is based on the split of stocks into two size groups according to the sample median. This method is followed by Miles and Timmermann (1996), Liu *et al* (1999), Fletcher (2001), Hussain *et al*

(2002), Fletcher and Forbes (2002) and Al-Horani *et al* (2003). This method ensures that the same number of stocks are allocated to each size group.

Gregory *et al* (2001) and Dimson *et al* (2003), however, adopt different approaches. Specifically, Dimson *et al* (2003) chose a wider range for small stocks. Their small size group contains the bottom 70% of each year's stocks. Gregory *et al* (2001) use the median of the largest 350 companies, rather than the whole sample, to define the break point for the size split. Arguably, the methods in these two papers attempt to mimic the methods of Fama and French (1993) who merge NYSE and NASDAQ data but use the median size breakpoint for NYSE firms to split firms by size. Fletcher and Kihanda (2005), on the other hand, use completely opposite method. They split stocks each year into ten deciles and compute the SMB factor as the difference between the smallest size decile return and the average return of the remaining nine size deciles.

There is a wider diversity in the method used to define the BM break points compared to those used for market value break points. The most common one in our examined papers is each year to split stocks into three groups as in Fama and French (1993). Namely, stocks in the lowest thirty percent of firms ranked by BM constitute the low BM (L) stocks, medium BM stocks (M) are in the middle forty percent and high BM stocks (H) are in the top thirty percent. Dimson *et al* (2003) and Gregory *et al* (2001) choose less extreme BM breakpoints. Dimson *et al* (2003) set the breakpoints at the 40th and 60th percentiles, while Gregory *et al* (2001) allocate stocks in an independent sort to three BM groups, low, middle, and high, based on the breakpoints of the bottom 30%, middle 40%, and top 30% of the values of BM recorded for the largest 350 firms at the end of the previous year.

Using subsequent sorts, Fletcher (2001) and Fletcher and Forbes (2002) split each size portfolio into three BM groups with exactly the same number of stocks. As a consequence, the BM breakpoints are relative to the particular size portfolio. Fletcher and Kihanda (2005) calculate the returns on HML factor as the difference in monthly returns between the Morgan Stanley Capital Investment (MSCI) UK value and growth indices and, hence, breakpoints are not relevant to their method. Table A.1, Panel C provides a summary of the breakpoints used.

4.5 The weighting method used in forming portfolio returns

The majority of the examined papers basically follow a form of value-weighted approach in computing the portfolio returns from which the SMB and HML returns are derived. Specifically, eight out of nine papers use this method, with the only exception being Fletcher (2001) who uses an equally-weighted approach.

Nevertheless, different strategies are applied within a general value-weighted approach, with different updating strategies for the weights. Specifically, Gregory *et al* (2001), Dimson *et al* (2003) and Fletcher and Kihanda (2005) used the value weights at the end of June as the weights for every month of the holding period. However, Liu *et al* (1999) use value weights defined at the end of June and December – weights are updated every six months. The remaining four papers applied the value-weighted method with weights defined by the market values at the beginning of each month.

Overall, we observe that there are a whole range of combinations of choices that are made in constructing SMB and HML factors in the UK within the general Fama and French (1993, 1996) framework. Generally, relatively little explanation is provided as to why choices are made. As Balvers (2001) points out, however, the choices made to generate the factors are arbitrary in the USA, and attempts to use 'similar' methods in the UK are equally as arbitrary. Only one paper completely steps away from the Fama and French (1993, 1996) framework but, again, little explanation is offered as to why. As a consequence, we treat all these factor construction methods as competing and arbitrary.

4.6 Test portfolios

We test the three factor models on two sets of test portfolios. The first set is based on sorting stocks by size and BM every June 30. Specifically, each year we independently sort stocks into quartiles based on size and BM.[10] Firm size is measured as the number of shares outstanding multiplied by the stock price at the end of June. BM is measured at the end of December of previous year. The intersection of these independent sorts gives us sixteen portfolios each year. For these sixteen portfolios, we then calculate value-weighted returns on the assumption that the portfolios are bought and held for a year. Repeating this process year by year results in a time series of portfolio monthly returns from July 1980 to December 2010.

Examination of untabulated summary statistics suggests that the average value-weighted return tends to increase as we move from low to high book-to-market firms. Not unlike the results in Table 2 above, there is no specific tendency in average returns across the size of firms, other than that the sub-portfolios formed from the small firm quartile have higher returns than those formed from the big firm quartile.[11]

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10 We use quartiles, as opposed to, for example, quintiles, because of the need for an adequate average number of firms in each intersected portfolio. The 'pressure point' here is the portfolio which intersects the largest firms with the firms with the highest BM. It is only when using quartiles that a sufficient number of firms are contained within the intersection.

11 The table is available from the authors upon request.

Lo and Mackinlay (1990) warn against solely using portfolios, formed on the basis of characteristics that are known to be associated with returns, in testing asset pricing models. Therefore, we also perform our asset pricing tests using the returns on twenty industry portfolios. We use the London Share Price Database industrial classification codes and the FTSE Industrial Classification Benchmark (ICB) to construct the twenty industry portfolios every month from July 1980 to December 2010. We estimate value-weighted monthly returns for these portfolios.

Insert Table 3 About Here

Table 3 provides summary statistics for the various SMB and HML factors. The mean SMB factors range from -.09% *per* month to 1.36% *per* month across the different estimation methods. The time series of SMB factors, for each of the methods, does not appear to be drawn from a normal distribution, as captured by the Jarque-Bera statistic. The means are positive and significant at the 5% level for five out of the nine methods, with the others indistinguishable from zero. Moreover, it is negative, if insignificant, for the methods of Gregory *et al* (2001) and Dimson *et al* (2003). The overall results suggest the possibility that, because the size effect is caused by the smallest companies (see Table 2 above), the return on the SMB factor declines and then disappears as more stocks find their way into the smallest size portfolios All the HML factors are positive, ranging from .12% *per* month to .71% *per* month. As with SMB, the distributions of the HML factors, *via* any estimation method, show significant departures from normality.[12] The factors are significantly positive for four methods.[13] Overall, we can conclude that the method of estimating SMB and HML matters in terms of whether size and value *premia* appear to exist using these approaches to their estimation.[14]

We now turn our attention to the correlations between the various factor time series, as a way of capturing the similarity between the factors produced by the different estimation methods. We capture the similarity by estimating the correlation matrix between different SMB factors and between different HML factors. A correlation coefficient of one between SMB factors means that they convey the same information and can be used interchangeably. However, low correlation will indicate that they capture different information and consequently may give us different conclusions, either as risk factors or as premium measures.

Looking to the correlations between the various factor time series, as a way of capturing the similarity between the factors produced by the different estimation methods, Table 4, Panel A shows the results for the SMB factor. The correlation matrix between SMB factors shows coefficients ranging from a low of .38 to a high of .98. Of the 36 coefficients, 6 are between .9 and 1, 10 are between .8 and .9, 10 are between .7 and .8, 7 are between .6 and .7

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12 Although all the different factors appear to be drawn from non-normal distributions, we note that the means of the SMB factors appear to be particularly affected by large positive maximum values in the time series of values for these factors, whereas the means of the HML factors appear to be particularly affected by low negative minimum values. As a consequence, the departures from non-normality do have the potential to affect conclusions about the means of the various factors.

13 As mentioned above, the methods of Gregory *et al* (2001) and Dimson *et al* (2003) could be seen as partially mimicking the factor construction methods in Fama and French (1993), where breakpoints are defined with respect to NYSE stocks only, but the factors are constructed from NYSE and NASDAQ stocks combined. Given the results in Table 2, the approaches of Gregory *et al* (2001) and Dimson *et al* (2003) could dampen down the effect of small firm observations with high returns by defining more firms as 'small' relative to other approaches.

14 We also estimate the correlation coefficients between different sets of HML and SMB and UK macroeconomic variables. The macroeconomic variables used are: (i) industrial production growth; (ii) inflation; (iii) real money supply; (iv) term spread; (v) default spread; (vi) long-term government bond yield; (vii) one year government bond yield; (viii) three month treasury bill rate; (ix) oil prices; and (x) input price index. The correlations are generally low. The results are available from the authors upon request.

and 3 are below .6. The average correlation coefficient suggests, in a rough and ready fashion, that the average R^2 in a regression of one factor on another is just over 50%. This suggests that these factors, whilst having overlap, are potentially quite different.

If we concentrate on those factors that have significantly means, although there are some high correlation coefficients (e.g., the correlations between SMBMT, SMBHTD and SMBFF all exceed .9), the coefficients involving SMBFK are all less than .76, and those involving SMBF are less than .41. Hence, even amongst the estimates of SMB with positive and significant average means, different methods of estimation appear to have the potential to produce factors with quite different information.

Insert Table 4 About Here

Table 4, Panel B shows the results for the HML factor. The correlation matrix between SMB factors shows coefficients ranging from a low of .13 to a high of .91. Of the 36 coefficients, 2 are between .9 and 1, 1 is between .8 and .9, 14 are between .7 and .8, 8 are between .6 and .7 and 11 are below .6. Generally speaking, the correlations between the different HML factors are lower than for the SMB factors. The use of the difference between the Morgan Stanley Capital Investment (MSCI) UK value and growth indices as a proxy for HML by Fletcher and Kihanda (2005) produces relatively low correlation coefficients with other HML factors. Again, the results suggest that these nine HML factors, as with SMB, whilst having overlap, are potentially quite different.

If we again concentrate on those factors that have significant means, we can observe that the correlations between HMLF and the other significant factors is less than .4 and even between the other two, it is under .79. Again, and perhaps even more so than for SMB factors, even amongst the positive and significant average mean estimates of SMB, different methods of estimation have the potential to produce factors with quite different information.[15]

A general conclusion of this section is that the method of factor construction seems to matter with respect to (i) the size of the factor mean; and (ii) whether the factor reveals a significant mean consistent with the existence of a risk premium associated with a particular firm characteristic. Further, judging by correlations between SMB and HML factors constructed using different methods, the different factors are not necessarily highly related to each other, suggesting a degree of dissimilarity between them. Whether this affects the performance of these factors within asset pricing models employing them is the issue we now turn to.

5 ASSET PRICING TEST RESULTS

5.1 Pricing portfolios

Reporting on our case study of the use of SMB and HML within FF three factor-based three factor models, in Tables 5 and 6 we provide estimates of the average intercept terms, and their associated t-statistics, estimated in the time series regressions of the excess returns on

[15] Miles and Timmermann (1996) argue that the success of any procedure for estimating SMB and HML depends mainly on the correlation between the time series of HML and SMB. In other words, the nearer to zero the correlation between the SMB and HML, the more successful is the estimation method. In untabulated estimates, in general, the correlations between the factors are negative, with few exceptions. They range from a low of -0.44 to a high of 0.08. In general, it would appear to be difficult to produce factors that are orthogonal to each other, whether adopting the methods of a single paper or mixing and matching between papers.

the sixteen portfolios sorted on size and BM and the twenty industry portfolios. We also present joint tests of the significance of the intercepts, computed by applying the GRS F-statistic.

Insert Table 5 About Here

We find that the estimated intercepts suggest that all of the various versions of the three factor model leave unexplained returns for some of the size-BM intersected portfolios, with a number of intercepts with individually significant t-statistics. The number of significant intercepts ranges from three (F) to eleven (MT). For each version of the three factor model, the difference between the highest and lowest intercept is normally at least 1% *per* month, although the significant intercepts are mainly negative. Additionally, the GRS F-test suggests that the intercepts are jointly significant, with the corresponding p-value being $< .01$, for each set of factors. As a consequence, none of the three factor models can appropriately price the size-BM intersected portfolios.

Further, it is not clear that it is one particular portfolio (for example, small firms with high book-to-market ratios), or set of portfolios, that the various models have difficulty pricing. Finally, the range of risk-adjusted performance estimates can be quite large. For example, the small firm/low BM portfolio has abnormal return estimates ranging from -.80% per month to .79% per month. It is only really for the big firm portfolios that risk-adjusted performance estimates tend to be relatively consistent in size. Finally, there is only one portfolio the abnormal pricing of which all the models agree on. For the other fifteen, some models will suggest abnormal returns, whilst others will suggest normal returns.

Insert Table 6 About Here

When the time-series regressions are estimated on the excess returns for the industry portfolios, we find that the number of significant intercepts ranges from one (DNQ, F, GHM) to eight (MT). Industries that appear to be particularly difficult to price, in terms of the number of significant intercepts, are Support Services and Utilities. Furthermore, the GRS F-test for the joint significance of the intercepts for each set of factors suggests that the intercepts are jointly significant using the methods of APS, FF, FK, HTD and MT, suggesting the joint mis-pricing of the industry portfolios. The methods of DNQ, F, GHM and LSX produce average intercepts consistent with these methods appropriately pricing the industry portfolios.[16]

Overall, we can conclude that none of the various sets of factors can price the size-BM portfolios reliably within the context of FF three factor-based asset pricing models. Furthermore, there is some evidence of an inability to price the set of industry portfolios on average, and certain industry portfolios seem particularly difficult to price.[17] Given the

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16 As mentioned above, Kan and Zhang (1999) suggest testing whether the loadings of the assets with respect to a particular factor are jointly significantly different from zero in the first-pass time-series regression before running the second pass cross-section regression. In untabulated results, we find that the p-values corresponding to the F-statistics from a seemingly unrelated regression for the joint significance of the loadings are all < .01. This applies to both sets of test portfolios. Hence, we can reject the null hypothesis that the SMB and HML factors are useless risk factors.

17 We can also report briefly on some extensions of our asset pricing tests. First, we use principal component analysis to produce composite SMB and HML factors and evaluate them on our tests assets

differences in performance between the various three factor models, we can also conclude that the methods of factor construction do appear to matter from an empirical point of view.

6 DISCUSSION AND CONCLUSIONS

Our investigation of the performance of different methods of constructing SMB and HML factors suggests the following. First, not all factors are associated with significant means, suggesting that they are not all capturing risk differences associated with firm size and book-to-market, even though those effects appear to be present in the data. Second, neither the SMB factors nor the HML factors appear highly similar. Third, as a case study in using the various sets of SMB and HML factors, our asset pricing tests suggest that nine FF three factor-based models using the sets of SMB and HML factors do not perform in a similar fashion in pricing either size/book-to-market portfolios or industry portfolios. Overall, these three observations suggest that factor construction methods can matter in the use of factor models and, as a consequence, factor construction methods need to be considered carefully in empirical settings. Finally, we can also conclude that the nine FF three factor-based models we assess cannot be relied upon to deliver reliable estimates of abnormal returns in all circumstances, even if some of them price industry portfolios acceptably well.

The results above pose difficulties for empirical researchers using UK data. First, it is not clear how to interpret past empirical research using UK data the conclusions of which rely on particular construction methods for SMB and HML. Could the application of other

within the context of a FF three factor-based model. They price all the industry portfolios appropriately and, as a consequence, outperform any of the individual factors. Their performance in pricing the size/book-to-market portfolios offers no improvement over the previous results, however. Second, we also add various factors to the three factors of the FF model. In particular, we add in momentum and/or asset/investment growth factors. These additions produce only minor improvements in performance, whether of the industry or the size/book-to-market portfolios. Details are available from the authors.

competing construction methods have produced different results? Our results cannot rule out this possibility. Second, given that most methods of constructing SMB and HML have attempted to apply the letter or the spirit of the Fama and French (1993) methods to the UK situation, with some attempts at adaptation to the differences between the UK and US stock markets, it is not clear that these techniques, given the empirical results in this paper, lead to reliable factors that reflect size and book-to-market effects in the UK market. This suggests that more work is needed to develop these measures, possibly from scratch but perhaps reflecting the specific ways in which these effects work in the UK stock markets, together with associated 'track-testing' within carefully chosen factor models, to ensure that risk control models are well-specified.[18]

But, if there is doubt that factor models are *currently* the best way to deal with controlling for risk in UK research, then what other possibilities exist? Another possibility is to match individual firm returns with the return on a benchmark portfolio formed on the basis of the firm characteristics thought to capture risk. The difficulty with this approach is that, because of the number of listed firms in the UK, it is difficult to match on any more than two risk characteristics, whereas evidence suggests that there are more than two characteristics with the potential to capture risk (see, for example, Dedman, *et al*, 2009, on the existence of RD effects in UK stock returns; but other effects exist, such as the association between past and future returns).

Finally, individual firm returns can be regressed on firm characteristics known to be associated with the cross-section of returns. In such an approach, a dummy variable could be associated with the event being studied (e.g., a takeover, a divestiture, an IPO), or a ranking

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18 Gregory *et al* (2013) make a start in this area, as well as considering a number of alternative specifications of factor models based upon the FF and Carhart (1997) models.

(e.g., of earnings surprises, as in post-earnings announcement drift, or accruals, as in the accruals anomaly). Whilst such an approach also carries with it difficulties with respect to some events for which firm characteristics could be hard to identify at the time of an event, it seems more likely to be able to cope with the complexity of the various effects in UK stock returns.[19]

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[19] We do not claim that this suggestion is original. In fact, this approach has been suggested in Gregory (1997) and an application of this approach can be found in Pincus, Rajgopal and Venkatachalam (2007). Any originality lies in identifying that this approach might become more attractive in the light of the evidence provided in this paper on the performance of factor models. Further, our suggestion is not meant to imply that it is not without its problems too. For example, which firm characteristics should be included, and might they be correlated with the event/variable of interest?

REFERENCES

Alexandridis, G., Antoniou, A., & Petmezas, D. (2007). Divergence of opinion and post-acquisition performance. *Journal of Business Finance and Accounting,* 34(3-4), 439-460.

Antoniou, A., Galariotis, A., & Spyrou, S.I. (2006). Short-term contrarian strategies in the London Stock Exchange: Are they profitable? Which factors affect them? *Journal of Business Finance and Accounting,* 33 (5-6), 839-867.

Al-Horani, A., Pope, P.F., & Stark, A.W. (2003). Research and development activity and expected returns in the United Kingdom. *European Finance Review,* 7(1), 27-46.

Ang, A. & Chen, J. (2007). CAPM over the long run: 1926-2001. *Journal of Empirical Finance,* 14(1), 1-40.

Avramov, D. & Chordia, T. (2006). Asset pricing models and financial market anomalies. *Review of Financial Studies*, 19(3), 1001-1040.

Balvers, R. (2001). Foundations of Asset Pricing (working paper), available on the internet at: http://www.be.wvu.edu/divecon/econ/balvers/assetpr.html.

Bauer, R., Cosemans, M., & Schotman, P. C. (2010). Conditional asset pricing and stock market anomalies in Europe. *European Financial Management,* 16(2), 165-190.

Carhart, M. (1997). On Persistence in Mutual Fund Performance. *Journal of Finance*, 52, 57–82.

Cochrane, J.H. (2001). *Asset Pricing*. NJ: Princeton University Press.

Dedman, E., Stark, A.W., Shen, Y. & Mouselli, S. (2009). Accounting, intangible assets, stock market activity and measurement and disclosure policy: Evidence from the UK, *Abacus,* 45(3), 312-341.

Dimson, E., Nagel, S., & Quigley, G. (2003). Capturing the value premium in the United Kingdom. *Financial Analysts Journal*, 59(6), 35-45.

Ecker, F. (2012). Asset pricing tests using realized returns. Available at http://faculty.fuqua.duke.edu/~fecker/Research.htm.

Fama, E.F. & French, K.R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics,* 33(1), 3-56.

Fama, E.F. & French, K.R. (1996). Multifactor explanations of asset pricing anomalies. *Journal of Finance,* 51(1), 55-84.

Fama, E.F. & French, K.R. (1998). Value versus growth: The international evidence. *Journal of Finance*, 53(6), 1975-1999.

Fama, E.F. & French, K.R. (2011). Size, Value, and Momentum in International Stock Returns. Available at: http://ssrn.com/abstract=1720139.

Fama, E.F. & MacBeth, J.D. (1973). Risk, return, and equilibrium: Empirical tests. *Journal of Political Economy,* 81(3), 607-636.

Fletcher, J. (2001). An examination of alternative factor models in UK stock returns. *Review of Quantitative Finance and Accounting,* 16(2), 117-130.

Fletcher, J. & Forbes, D. (2002). U.K. unit trust performance: Does it matter which benchmark or measure is used? *Journal of Financial Services Research*, 21(2), 195-218.

Fletcher, J. & Kihanda, J. (2005). An examination of alternative CAPM-based models in UK stock returns. *Journal of Banking and Finance,* 29(12), 2995-3014.

Gibbons, M.R., Ross, S.A., & Shanken, J.(1989). A test of the efficiency of a given portfolio. *Econometrica,* 57(5), 1121-1152.

Gregory, A. (1997), An Examination of the Long Run Performance of UK Acquiring Firms, *Journal of Business Finance and Accounting*, .24(7&8), 971-1002.

Gregory, A., Harris, R.D.F., & Michou, M. (2001). An analysis of contrarian investment strategies in the UK. *Journal of Business Finance and Accounting,* 28(9&10), 1192-1228.

Gregory, A., Tharyan, R., & Christidis, A. (2013). Constructing and testing alternative versions of the Fama-French and Carhart models in the UK. *Journal of Business Finance and Accounting*, 40(1&2), 172-214.

Hussain, S.I., Toms, J.S., & Diacon, S. (2002). Financial distress, market anomalies and single and multifactor asset pricing models: New evidence (working paper), Available at: http://ssrn.com/abstract=313001.

Kan, R. & Zhang, C. (1999). Two-pass tests of asset pricing models with useless factors. *Journal of Finance,* 54(1), 203-235.

Liu, W., Strong, N., & Xu, X. (1999). The profitability of momentum investing. *Journal of Business Finance and Accounting,* 26(9&10), 1043-1091.

Lo, A. & MacKinlay, A.C. (1990). Data-snooping biases in tests of financial asset pricing models. *Review of Financial Studies,* 3(3), 431-467.

Miles, D. & Timmermann, A. (1996). Variation in expected stock returns: Evidence on the pricing of equities from a cross-section of UK companies. *Economica,* 63(251), 369-382.

Pincus, M., Rajgopal, S., & Venkatachal, M. (2007), The Accrual Anomaly: International Evidence, *The Accounting Review*, 82(1), 169-203.

TABLE 1	
Sample Observations by Year	
Year	*Number of Firms by Year*
1980	731
1981	734
1982	759
1983	792
1984	818
1985	884
1986	934
1987	995
1988	1034
1989	1075
1990	1061
1991	988
1992	1041
1993	1020
1994	1044
1995	1061
1996	1051
1997	1212
1998	1280
1999	1180
2000	1081
2001	1066
2002	1070
2003	1018
2004	942
2005	912
2006	1063
2007	1083
2008	1041
2009	958
2010	878
Total	30806

Note:

The year column represents the year in which returns data are available (e.g., 2002 represents the returns data used in that year to construct portfolios from July 2002 to April 2003).

TABLE 2		
Descriptive Statistics for % Returns for Deciles Sorted on Size and Book-to-Market for the Period 1980(7) - 2010(12)		
Panel A: Size Deciles		
Size decile	*Average % returns*	*Value-weighted % returns*
P1	3.03	2.43
P2	1.75	1.69
P3	1.49	1.44
P4	1.07	1.02
P5	1.20	1.15
P6	1.09	1.05
P7	1.16	1.15
P8	1.11	1.07
P9	1.26	1.22
P10	1.27	1.15
Panel B: Book-to-Market Deciles		
BM decile	*Average % returns*	*Value-weighted % returns*
P1	0.86	0.73
P2	1.01	1.05
P3	1.03	0.78
P4	1.35	1.25
P5	1.33	1.44
P6	1.40	1.35
P7	1.55	1.39
P8	1.71	1.70
P9	1.98	1.78
P10	2.06	1.90

Note:

We sort stocks into deciles (P1 being the lowest and P10 being the highest) according to size and BM on June 30 of every year. Size is measured as the number of shares outstanding multiplied by the stock price at the end of June. BM is measured at the end of December of previous year. Specifically, the BM used to sort stocks on June 30 of year t is measured using the firm market value at the end of December year t-1. Book value is taken from the balance sheet for the financial year ending during the calendar year t-1. Book value is defined as equity capital and reserves (net assets) minus total intangibles – one of the more common definitions for book value used in the UK (see Table 3). We report the average monthly average and value-weighted returns for these deciles over the period July 1980 to December 2010.

TABLE 3

Estimated Size and Value *Premia* From the Different SMBs and HMLs (%)

Panel A: Estimated Size *Premia* From SMB Factors

	SMBAPS	*SMBDNQ*	*SMBF*	*SMBFF*	*SMBFK*	*SMBGHM*	*SMBHTD*	*SMBLSX*	*SMBMT*
Mean	**1.23**	-0.08	**0.48**	**1.26**	**1.36**	-0.09	**1.34**	0.19	**1.22**
Median	0.59	-0.14	0.40	0.58	1.00	-0.29	0.61	-0.07	0.67
Maximum	32.44	16.77	16.65	36.59	25.93	15.67	51.64	33.19	28.45
Minimum	-10.14	-14.48	-7.25	-8.88	-11.70	-12.84	-9.60	-11.79	-10.51
Std. Dev.	5.29	3.68	2.65	4.90	5.15	3.29	5.51	4.20	4.94
Skewness	2.32	0.26	0.66	2.12	0.73	0.24	3.41	1.42	1.77
Kurtosis	14.13	5.45	6.84	13.58	5.17	5.18	26.01	12.98	10.33
Jarque-Bera	2218.17	95.87	251.64	1981.60	104.64	75.69	8778.19	1641.10	1011.03
Probability	< .01	< .01	< .01	< .01	< .01	< .01	< .01	< .01	< .01
Newey-West t-statistic	3.07*	-0.38	2.72*	3.51*	4.02*	-0.48	3.39*	0.75	3.26*
Observations	366	366	366	366	366	366	366	366	366

* implies the mean factor return is significantly different from zero at the 5% level of significance, using a two-tailed test.
** implies the mean factor return is significantly different from zero at the 10% level of significance, using a two-tailed test.

TABLE 3 *continued*									
Panel B: Estimated Value *Premia* From the HML Factors									
	HMLAPS	*HMLDNQ*	*HMLF*	*HMLFF*	*HMLFK*	*HMLGHM*	*HMLHTD*	*HMLLSX*	*HMLMT*
Mean	0.42	**0.51**	**0.71**	0.38	0.12	**0.72**	0.29	**0.66**	0.54
Median	0.53	0.40	0.67	0.58	0.18	0.58	0.65	0.68	0.67
Maximum	12.56	11.72	13.63	14.18	10.75	17.74	19.86	17.90	12.47
Minimum	-24.67	-17.12	-19.45	-28.85	-9.63	-15.77	-56.16	-27.46	-31.43
Std. Dev.	3.53	2.49	2.91	3.56	2.84	3.05	5.04	3.53	3.88
Skewness	-1.68	-0.55	-1.42	-3.12	0.01	0.22	-5.25	-1.16	-2.98
Kurtosis	15.00	11.45	16.01	28.07	4.54	9.39	56.48	17.92	27.51
Jarque-Bera	2367.87	1107.15	2703.93	10176.87	36.34	625.34	45304.95	3474.29	9703.87
Probability	< .01	< .01	< .01	< .01	< .01	< .01	< .01	< .01	< .01
Newey-West t-statistic	1.61	3.07*	2.98*	1.48	0.85	3.26*	0.99	2.54*	1.93
Observations	366	366	366	366	366	366	366	366	366

* implies the mean factor return is significantly different from zero at the 5% level of significance, using a two-tailed test.

TABLE 4

Correlations within SMB and HML Factors

Panel A: SMB Factors									
	SMBAPS	*SMBDNQ*	*SMBF*	*SMBFF*	*SMBFK*	*SMBGHM*	*SMBHTD*	*SMBLSX*	*SMBMT*
SMBAPS	1.00000	0.79572	0.645725	0.974856	0.696092	0.762771	0.963656	0.854602	0.977585
SMBDNQ		1.00000	0.505665	0.801092	0.639312	0.895778	0.747931	0.845514	0.805443
SMBF			1.00000	0.655013	0.828976	0.382324	0.606575	0.706374	0.648991
SMBFF				1.00000	0.71675	0.780441	0.96248	0.847494	0.967058
SMBFK					1.00000	0.574869	0.655475	0.739721	0.710027
SMBGHM						1.00000	0.722851	0.836084	0.772879
SMBHTD							1.00000	0.811274	0.945668
SMBLSX								1.00000	0.858885
SMBMT									1.00000

Panel B: HML Factors									
	HMLAPS	*HMLDNQ*	*HMLF*	*HMLFF*	*HMLFK*	*HMLGHM*	*HMLHTD*	*HMLLSX*	*HMLMT*
HMLAPS	1.00000	0.756397	0.729165	0.912258	0.382861	0.724408	0.643674	0.707215	0.909669
HMLDNQ		1.00000	0.654367	0.744941	0.461588	0.758516	0.419784	0.653392	0.72419
HMLF			1.00000	0.79637	0.242413	0.721634	0.492269	0.664749	0.695285
HMLFF				1.00000	0.395254	0.743623	0.643582	0.728976	0.867828
HMLFK					1.00000	0.37553	0.138431	0.354114	0.419502
HMLGHM						1.00000	0.53785	0.712807	0.657769
HMLHTD							1.00000	0.526975	0.611772
HMLLSX								1.00000	0.712459
HMLMT									1.00000

TABLE 5

Abnormal Return Estimates From the Various FF Models on Size-BM Portfolios

	Low	2	3	High		Low	2	3	High	
	α					t_{α}				F
APS										
Small	**-0.67**	**-0.58**	*-0.29*	0.08		**-2.73**	**-2.34**	*-1.66*	0.52	**9.53**
2	**-1.28**	**-1.05**	**-0.83**	**-0.46**		**-7.62**	**-5.81**	**-4.79**	**-2.78**	**< .01**
3	**-1.10**	**-0.65**	**-0.61**	-0.34		**-5.71**	**-4.48**	**-3.44**	-1.77	
Big	-0.11	0.02	0.15	*0.31*		-1.02	0.14	1.18	*1.77*	
DNQ										
Small	0.54	*0.45*	**0.57**	**0.85**		1.58	*1.70*	**3.33**	**5.93**	**4.99**
2	-0.17	-0.17	-0.13	**0.35**		-0.88	-1.27	-1.15	**2.61**	**< .01**
3	**-0.28**	0.03	0.02	0.15		**-2.02**	0.26	0.12	1.13	
Big	-0.06	0.03	0.07	*0.28*		-0.62	0.23	0.53	*1.69*	
F										
Small	-0.01	-0.18	-0.05	0.07		-0.01	-0.77	-0.25	0.40	**3.11**
2	**-0.49**	**-0.59**	**-0.61**	-0.28		**-1.97**	**-2.67**	**-2.81**	-1.33	**< .01**
3	-0.31	-0.11	-0.32	-0.12		-1.32	-0.51	-1.43	-0.55	
Big	-0.04	0.01	0.12	0.29		-0.33	0.04	0.85	1.44	
FF										
Small	**-0.60**	*-0.48*	-0.23	0.09		**-2.37**	*-1.87*	-1.29	0.56	**8.43**
2	**-1.24**	**-0.97**	**-0.81**	**-0.46**		**-7.34**	**-5.20**	**-4.48**	**-2.57**	**< .01**
3	**-1.03**	**-0.62**	**-0.61**	-0.31		**-5.20**	**-4.21**	**-3.31**	-1.53	
Big	-0.11	0.04	0.15	**0.36**		-1.08	0.23	1.17	**1.98**	
FK										
Small	**-0.80**	**-0.67**	-0.26	0.17		**-3.41**	**-2.91**	-1.49	1.04	**5.37**
2	**-1.21**	**-0.91**	**-0.62**	-0.11		**-4.98**	**-4.38**	**-3.07**	-0.52	**< .01**
3	**-1.10**	**-0.43**	-0.35	-0.04		**-5.23**	**-2.28**	-1.63	-0.18	
Big	**-0.24**	0.19	**0.31**	**0.50**		**-2.12**	1.21	**2.10**	**2.70**	

GHM										
Small	**0.79**	*0.56*	**0.71**	**0.94**		**2.04**	*1.79*	**3.40**	**5.62**	**4.64**
2	0.05	-0.06	-0.06	**0.45**		0.26	-0.32	-0.42	**2.99**	**< .01**
3	-0.10	0.13	0.04	0.18		-0.94	1.27	0.34	1.33	
Big	0.07	0.00	-0.05	0.20		0.82	-0.01	-0.44	1.22	
HTD										
Small	**-0.74**	**-0.66**	*-0.35*	0.05		**-2.64**	**-2.73**	*-1.91*	0.32	**8.64**
2	**-1.34**	**-1.11**	**-0.88**	**-0.54**		**-7.02**	**-5.79**	**-4.38**	**-3.18**	**< .01**
3	**-1.20**	**-0.66**	**-0.69**	*-0.36*		**-6.23**	**-4.07**	**-3.62**	*-1.73*	
Big	-0.09	0.06	0.19	**0.38**		-0.92	0.37	1.37	**2.20**	
LSX										
Small	0.26	0.10	**0.28**	**0.59**		0.99	0.46	**1.97**	**4.42**	**5.55**
2	**-0.55**	**-0.51**	**-0.42**	0.03		**-3.65**	**-3.67**	**-3.62**	0.20	**< .01**
3	**-0.61**	**-0.25**	*-0.27*	-0.04		**-4.08**	**-2.03**	*-1.79*	-0.27	
Big	-0.08	0.03	0.08	0.26		-0.80	0.24	0.66	1.46	
MT										
Small	**-0.69**	**-0.58**	**-0.33**	0.01		**-2.68**	**-2.30**	**-1.96**	0.04	**8.85**
2	**-1.33**	**-1.06**	**-0.89**	**-0.51**		**-7.71**	**-6.11**	**-5.22**	**-3.07**	**< .01**
3	**-1.16**	**-0.72**	**-0.69**	**-0.38**		**-6.16**	**-5.17**	**-3.98**	**-2.02**	
Big	-0.12	0.02	0.14	*0.31*		-1.06	0.16	1.13	*1.69*	

Notes:

(i) This table reports the intercepts from time-series regressions applying the Fama-French models to 16 size-book-to-market portfolios.
(ii) The corresponding t-statistics are also reported and they are corrected for heteroscedasticity and serial correlation, using the Newey-West estimator with five lags.
(iii) The sample period is from July 1980 to December 2010.
(iv) The last column reports F-statistics, and their corresponding p-values, from a GRS F-test, testing the joint significance of the intercepts.
(v) The intercepts are in percentages.

TABLE 6

Abnormal Return Estimates From the Various FF Models on Industry Portfolios

Industry		APS	DNQ	F	FF	FK	GHM	HTD	LSX	MT
Oil and Gas	α	-0.25	-0.14	-0.12	-0.22	-0.11	-0.22	-0.25	-0.08	-0.20
	t_α	-0.56	-0.34	-0.30	-0.51	-0.26	-0.54	-0.55	-0.19	-0.44
Chemicals	α	-0.10	0.04	-0.04	-0.08	0.01	-0.03	-0.11	0.03	-0.10
	t_α	-0.45	0.22	-0.20	-0.38	0.01	-0.16	-0.53	0.16	-0.48
Basic Resources	α	0.00	0.14	0.18	0.01	0.20	0.11	-0.03	0.11	-0.06
	t_α	0.01	0.40	0.43	0.03	0.52	0.32	-0.08	0.31	-0.14
Construction and Materials	α	**-0.42**	-0.20	-0.22	-0.41	-0.15	-0.26	*-0.40*	*-0.36*	**-0.44**
	t_α	**-2.06**	-1.15	-1.03	-2.03	-0.66	-1.57	*-1.84*	*-1.90*	**-2.12**
Aerospace and Defence	α	0.03	0.13	0.09	0.01	0.19	0.15	0.02	0.08	-0.05
	t_α	0.11	0.48	0.30	0.04	0.66	0.56	0.07	0.28	-0.16
General Industrials	α	-0.28	0.09	-0.12	-0.27	-0.16	0.10	-0.29	-0.05	-0.32
	t_α	-0.93	0.36	-0.38	-0.89	-0.52	0.40	-0.91	-0.17	-1.07
Electronic and Electrical Equipment	α	-0.41	0.16	0.61	-0.39	-0.17	0.32	*-0.48*	-0.09	*-0.45*
	t_α	-1.56	0.55	1.32	-1.47	-0.59	1.03	*-1.72*	-0.35	*-1.68*
Industrial Engineering	α	-0.41	-0.15	-0.16	**-0.47**	-0.19	-0.19	**-0.49**	-0.30	**-0.51**
	t_α	-1.56	-0.76	-0.71	**-2.30**	-0.81	-1.03	**-2.34**	-1.55	**-2.42**
Industrial Transportation	α	**-0.49**	-0.20	-0.28	**-0.45**	-0.33	-0.22	*-0.44*	-0.32	**-0.51**
	t_α	**-2.41**	-0.94	-1.13	**-1.96**	-1.49	-1.05	*-1.84*	-1.43	**-2.20**
Support Services	α	*-0.44*	**-0.25**	-0.21	**-0.63**	**-0.52**	*-0.20*	**-0.67**	**-0.42**	**-0.68**
	t_α	*-1.89*	**-1.97**	-1.22	**-4.41**	**-3.14**	*-1.65*	**-4.40**	**-3.17**	**-4.79**
Automobiles and Parts	α	**-0.64**	-0.05	-0.35	-0.41	-0.10	-0.09	-0.49	-0.33	-0.49
	t_α	**-4.57**	-0.14	-0.91	-0.95	-0.26	-0.23	-1.13	-0.85	-1.11
Food and Beverages	α	-0.40	0.14	0.00	0.17	*0.31*	-0.01	0.17	0.11	0.15
	t_α	-0.98	0.78	-0.01	1.10	*1.87*	-0.04	1.07	0.67	0.94
Personal and Household Goods	α	0.19	0.03	0.01	-0.16	0.18	-0.08	-0.11	-0.13	-0.18
	t_α	1.27	0.12	0.02	-0.58	0.59	-0.30	-0.40	-0.49	-0.62

Healthcare	α	-0.09	0.33	0.22	*0.48*	0.38	*0.41*	**0.53**	0.39	**0.54**
	t_α	-0.33	1.34	0.77	*1.84*	1.42	*1.73*	**2.04**	1.58	**2.04**
Food and Drug Retailers	α	**0.55**	0.18	0.12	0.31	*0.39*	0.06	0.34	0.18	0.32
	t_α	**2.15**	0.84	0.54	1.50	*1.91*	0.30	1.60	0.91	1.50
General Retailers	α	0.33	0.17	0.20	0.15	0.21	0.13	0.14	0.00	0.08
	t_α	1.58	0.67	0.70	0.55	0.76	0.48	0.52	0.01	0.30
Media	α	0.13	0.14	0.18	-0.15	-0.32	0.28	-0.24	0.02	-0.18
	t_α	0.48	0.55	0.75	-0.67	-1.44	1.09	-1.09	0.08	-0.79
Travel and Leisure	α	-0.23	-0.24	-0.25	**-0.52**	-0.19	*-0.31*	**-0.48**	**-0.37**	**-0.53**
	t_α	-1.03	-1.37	-1.24	**-2.93**	-0.95	*-1.91*	**-2.55**	**-2.14**	**-2.97**
Technology	α	**-0.52**	-0.02	0.42	**-0.75**	**-0.92**	0.32	**-0.92**	-0.38	**-0.85**
	t_α	**-2.87**	-0.05	1.28	**-2.10**	**-2.28**	0.95	**-2.46**	-0.93	**-2.16**
Utilities	α	**-0.87**	0.33	**0.53**	**0.48**	**0.45**	**0.49**	**0.54**	**0.46**	**0.48**
	t_α	**-2.40**	1.53	**2.49**	**2.20**	**1.97**	**2.41**	**2.48**	**2.18**	**2.15**
	F-stat	**2.11**	0.85	1.24	**1.93**	**1.72**	1.30	**2.09**	1.29	**2.03**
	p-value	**< .01**	0.65	0.21	**< .01**	**0.02**	0.17	**< .01**	0.17	**< .01**

Notes:

(i) This table reports the intercepts from time-series regressions applying the Fama-French model to 20 industry portfolios.
(ii) The corresponding t-statistics are also reported and they are corrected for heteroscedasticity and serial correlation, using the Newey-West estimator with five lags.
(iii) The sample period is from July 1980 to December 2010.
(iv) The last two rows reports F-statistics, and their corresponding p-values, from a GRS F-test, testing the joint significance of the intercepts.
(v) The intercepts are in percentages.

APPENDIX

TABLE A.1

PANEL A: Book Value Definitions

Paper	*Book Value Definition*
Al-Horani *et al*. – APS (2003)	Equity capital and reserves
Dimson *et al*. – DNQ (2003)	Equity capital and reserves *plus* deferred and future taxation
Fletcher - F (2001)	Equity capital and reserves
Fletcher and Forbes - FF (2002)	Equity capital and reserves
Fletcher and Kihanda – FK (2005)	N/A
Gregory *et al*. - GHM (2001)	Equity capital and reserves *minus* total intangibles
Hussain *et al*. - HTD (2002)	Equity capital and reserves *minus* total intangibles
Liu *et al*. - LSX (1999)	Equity capital and reserves *minus* total intangibles
Miles and Timmermann – MT (1996)	Equity capital and reserves

PANEL B: Sorting Method

Paper	*Method*
Al-Horani *et al*. – APS (2003)	Independent sort
Dimson *et al*. – DNQ (2003)	Independent sort
Fletcher - F (2001)	Subsequent sort
Fletcher and Forbes - FF (2002)	Subsequent sort
Fletcher and Kihanda – FK (2005)	MV sort only
Gregory *et al*. - GHM (2001)	Independent sort
Hussain *et al*. - HTD (2002)	Independent sort
Liu *et al*. - LSX (1999)	Independent sort
Miles and Timmermann – MT (1996)	Subsequent sort

PANEL C: Book-to-Market and Market Value Breakpoints

Papers	*Breakpoints for Market Value*	*Breakpoints for Book-to-Market*
Al-Horani *et al*. – APS (2003)	Median of the Sample	30th and 70th percentiles
Dimson *et al*. – DNQ (2003)	70th percentile	40th and 60th percentiles
Fletcher - F (2001)	Median of the Sample	One third for each size portfolio
Fletcher and Forbes - FF (2002)	Median of the Sample	One third for each size portfolio
Fletcher and Kihanda – FK (2005)	10^{th} percentile	MSCI value-MSCI growth
Gregory *et al*. - GHM (2001)	Median of the largest 350 MV firms	30th and 70th percentiles of largest 350 MV firms
Hussain *et al*. - HTD (2002)	Median of the Sample	30th and 70th percentiles
Liu *et al*. - LSX (1999)	Median of the Sample	30th and 70th percentiles
Miles and Timmermann – MT (1996)	Median of the Sample	30th and 70th percentiles